

**PLASMA DISPLAY PANEL MANUFACTURING METHOD
AND
HEAT TREATMENT APPARATUS**

5 The present disclosure relates to the subject matter contained in Japanese Patent Application No.2002-373379 filed on December 25, 2002, which is incorporated herein by reference in its entirety.

10 BACKGROUND OF THE INVENTION

1. Field of the Invention

 The present invention relates to a plasma display panel manufacturing method and a heat treatment apparatus.

2. Description of the Related Art

15 First, the structure of a common plasma display panel (referred to below as a PDP) will be described below as an example of a plasma display panel. Fig. 1 is an exploded perspective diagram showing the internal structure of the PDP, and Fig. 2 is a plan diagram schematically showing the
20 structure of row electrode pairs 2 (X, Y) of the PDP.

 In Fig. 1, plural row electrode pairs 2 (X, Y), a dielectric layer 3 that covers the row electrode pairs 2 (X, Y) and a protective layer 4 including MgO that covers the dielectric layer 3 are successively formed on an inner
25 surface of a front panel 1 that serves as a display surface.

Each row electrode pair 2 includes a transparent electrode 2a, which has a wide transparent conductive film such as ITO, and a metal electrode (bus electrode) 2b, which has a narrow metal film that supplements the conductivity of the

5 transparent electrode 2a.

On the other hand, partition walls 9 and phosphor layers 7R, 7G, and 7B of the three primary colors are formed on a back-side back glass panel 5, which is disposed so as to face the front panel 1 via the discharge space 8. The partition
10 walls 9 are aligned in a direction orthogonal to the row electrode pairs 2 (X, Y), are disposed in bands between column electrodes 6 to form a display cell at each intersection portion, and partition a discharge space 8. The phosphor layers 7R, 7G and 7B of the three primary colors
15 are disposed so as to cover the column electrodes 6 and side surfaces of the partition walls 9 with respect to the discharge space 8. A noble gas is charged and sealed inside the discharge space 8.

As shown in Fig. 2, the row electrode pairs 2 (X, Y)
20 are alternately aligned column-wise so as to correspond to one line L of a matrix display and be adjacent at each line L with a discharge gap G sandwiched therebetween. At each line L, a display cell (discharge cell) is demarcated into unit light-emitting regions E by the row electrode pairs
25 2 (X, Y).

Next, the display operation of the display in the above PDP will be described.

First, ON cells (cells in which a wall charge is formed) and OFF cells (cells in which a wall charge is not formed) are selected by an address operation resulting from selective discharge between the column electrodes 6 and the row electrode pairs 2 (X, Y) shown in Fig. 2. After the address operation, a discharge sustain pulse is applied, with respect to the row electrode pairs X and Y, at once to all of the lines L, whereby surface discharge arises in the ON cells each time the discharge sustain pulse is applied. The phosphor layers 7R, 7G and 7B are excited by ultraviolet light generated by this surface discharge and caused to emit visible light.

[Patent Document 1]

JP-A-11-149873 (p. 2, Figs. 7 and 8)

In the process of manufacturing a PDP such as the one described above, a heat treatment step is included in part of a formation step of a structure such as the electrodes, the partition walls, the phosphor layers, the dielectric layer and a black stripe layer. For instance, in the formation step of the dielectric layer, a glass paste including a mixture of glass powder, resin and a solvent is coated on a substrate, and the coated substrate is heat treated using a heat treatment apparatus such as a kiln.

A method of discharging exhaust gas of the heat treatment apparatus used in the heat treatment step will be described using the schematic diagram of Fig. 3, which shows a heat treatment apparatus.

5 As shown in Fig. 3, plural (three) exhaust pipes 111 are disposed at an upper portion of a heat treatment apparatus 110, and exhaust gas 112 generated from the inside of the heat treatment apparatus 110 is discharged from each exhaust pipe 111 to the outside (the atmosphere) of the heat
10 treatment apparatus 110.

 Thus, in the heat treatment step during the manufacture of the PDP, although resin components and solvent components are vaporized and removed at the time of the heat treatment, they are included as impurities in the exhaust gas 112 of
15 the heat treatment apparatus 110. There is the potential for them to be diffused to the outside (the atmosphere) when they are discharged from the exhaust pipes 111.

SUMMARY OF THE INVENTION

20 Eliminating the problem occurring in the aforementioned prior art—i.e., preventing the diffusion to the outside (the atmosphere) of impurities generated in a heat treatment step during the manufacture of a PDP—can be given as one example of the problem that the invention
25 attempts to solve.

In order to achieve this object, according to a first aspect of the invention, a plasma display panel manufacturing method includes forming a structure, wherein the forming of the structure includes forming a precursor layer containing at least one of a resin component and a solvent component on a substrate, and heat-treating the substrate on which the precursor layer has been formed; and decomposing impurities included in exhaust gas generated in the heat treatment by action of a catalyst.

Also, according to a second aspect of the invention, a heat treatment apparatus is used in a heat treatment where a substrate on which a precursor layer including at least one of a resin component and a solvent component is formed, is heat-treated. The heat treatment apparatus includes a catalyst unit including a catalyst disposed on an exhaust path where an exhaust gas generated in the heat treatment is discharged.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an exploded perspective diagram showing the internal structure of a PDP.

Fig. 2 is a plan diagram schematically showing the structure of row electrode pairs of the PDP.

Fig. 3 is a schematic diagram describing an exhaust gas exhaust method of a heat treatment apparatus.

Fig. 4 is a schematic front diagram showing heat treatment apparatus exhaust paths for describing an exhaust method of a heat treatment apparatus in a PDP manufacturing method of an embodiment pertaining to the invention.

5 Fig. 5 is a schematic plan diagram showing the heat treatment apparatus exhaust paths for describing an exhaust method of the heat treatment apparatus in the PDP manufacturing method of the embodiment pertaining to the invention.

10 Fig. 6 is a cross-sectional diagram showing an example of the configuration of a catalyst unit.

Fig. 7 is a diagram describing a catalyst of a honeycomb structure.

15 Figs. 8 are a Graph (a) of purified properties (degree of purification with respect to catalyst inlet gas temperature) when various substances included in untreated exhaust gas have been purified using a metal honeycomb structure and a Table (b) of the concentration and space velocity of the various substances.

20 Fig. 9 is an explanatory diagram showing an example of a purification reaction when platinum (Pt) is used for a catalyst-active substance.

Fig. 10 shows a table in which the properties of various catalysts are structurally/compositionally-distinguished
25 and compared.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

An embodiment of the invention will be described in detail below with reference to the drawings.

5 A plasma display panel (PDP) manufacturing method according to the embodiment of the invention includes a heat treatment step, such as drying, calcinating or baking, in part of a formation step of a structure (structure formation step) of electrodes, partition walls, phosphor layers, a
10 dielectric layer or a black stripe layer (outside light reflection prevention layer) of the PDP. The heat treatment step is one in which a paste-like material layer (a precursor layer including a resin component and/or a solvent component) that is formed on a substrate and serves as a
15 structure are heat-treated by a heat treatment apparatus (a drying furnace, a kiln or a baking furnace).

 The present embodiment is characterized in that impurities are removed and discharged from exhaust gas including a resin component and a solvent component
20 generated in the heat treatment step. A heat treatment apparatus and a method of discharging the exhaust gas, which are characteristics of the present embodiment, will be described in detail below with reference to the drawings.

 Fig. 4 is a schematic front diagram showing exhaust
25 paths of the heat treatment apparatus according to the

embodiment of the invention. Fig. 5 is a plan diagram thereof.

As shown in Fig. 4, plural (three) first exhaust pipes 11 (11a, 11b and 11c) are disposed as exhaust paths at an upper portion of a heat treatment apparatus (baking furnace) 10. Exhaust gases 12 (12a, 12b and 12c) generated from the inside of the heat treatment apparatus 10 are discharged to the respective exhaust pipes 11 (11a, 11b and 11c).

As shown in Fig. 5, inlets of catalyst units 13 (13a, 13b and 13c) are connected to outlets of the first exhaust pipes 11 (11a, 11b and 11c), and second exhaust pipes 14 (14a, 14b and 14c) are connected to outlets of the catalyst units 13 (13a, 13b and 13c). Additionally, exhaust gases 15 (15a, 15b and 15c) are discharged from exhaust openings 16 (16a, 16b and 16c) of the second exhaust pipes 14 (14a, 14b and 14c) to the outside (e.g., the atmosphere) of the heat treatment apparatus 10.

It should be noted that, although there are three systems of exhaust paths in the present embodiment, the number of exhaust paths, the number of disposed exhaust pipes and the number of disposed catalyst units can be made optional.

Also, the first exhaust pipes 11, the catalyst units 13 and the second exhaust pipes 14 in the exhaust paths may

be respectively disposed at optional angles as long as the exhaust gas is capable of being discharged.

In the present embodiment, because the exhaust paths of the heat treatment apparatus 10 are configured as
5 described above, a chemical reaction with respect to impurities included in the exhaust gases 12 flowing into each of the first exhaust pipes 11 is accelerated by catalysts of the catalyst units 13. As a result, the impurities included in the exhaust gases 12 are decomposed, become
10 harmless exhaust gases 15 (e.g., water vapor and carbon dioxide) and are discharged to the outside (e.g., the atmosphere) of the heat treatment apparatus 10.

It should be noted that it is preferable to administer a heating/protective countermeasure for preventing
15 condensation at the vicinities (particularly portions disposed substantially horizontally) of the first exhaust pipes 11.

Examples of the structure formation step in the PDP manufacturing method of the present embodiment include a bus
20 electrode formation step, a partition wall formation step, a phosphor layer formation step and a black stripe layer (outside light reflection prevention layer) formation step.

The bus electrode formation step is, for example, a step where a glass paste including a mixture of silver powder,
25 glass powder, resin and a solvent is coated to form a

precursor layer having a dielectric layer, the dielectric layer precursor layer is transferred to a substrate, and this is calcinated thereafter.

Also, the partition wall formation step is, for example,
5 a step where a glass paste including a mixture of glass powder, resin and a solvent is coated as a thick film on a substrate and dried, sandblasted via a predetermined mask, and this is calcinated thereafter.

Also, the phosphor layer formation step is, for example,
10 a step where a phosphor paste including a mixture of phosphor powder, resin and a solvent is filled and coated between partition walls, and this is calcinated thereafter.

Also, the black stripe layer (outside light reflection prevention layer) formation step is, for example, a step
15 where black paste including a mixture of an inorganic black pigment, resin and a solvent is coated between bus electrodes forming non-display lines, and this is calcinated thereafter.

Fig. 6 is a cross-sectional diagram showing an example
20 of the configuration of each catalyst unit 13.

As shown in Fig. 6, pipe connectors 17a and 17b are disposed in the catalyst unit 13. The pipe connectors 17a and 17b are respectively connected to the first exhaust pipe 11, into which the untreated exhaust gas 12 flows, and the
25 second exhaust pipe 14, which discharges the purified

exhaust gas 15. An exhaust heating heater 18, which is used in accordance with the need for catalyst stability, a filter 19, which is used when a lot of mist or the like is included in the untreated exhaust gas 12, and a catalyst 20 are
5 interconnected from the pipe connector 17a connected to the first exhaust pipe 11 towards the pipe connector 17b connected to the second exhaust pipe 14.

In the case of this example configuration, the untreated exhaust gas 12 flowing in from the pipe connector 17a
10 connected to the first exhaust pipe 11 is first warmed by the exhaust heating heater 18 to a suitable temperature so that it easily reacts due to the action of the catalyst. Next, impurities whose volume is large, such as mist, are removed by the filter 19. Finally, in the catalyst 20, the impurities
15 chemically react due to the action of the catalyst 20, are changed to harmless substances, and discharged from the second exhaust pipe 14 to the outside as the purified exhaust gas 15.

It should be noted that the exhaust heating heater 18
20 and the filter 19 do not always have to be used and may be used as needed.

Next, a table in which the properties of various catalysts are structurally/compositionally-distinguished and compared will be shown in Fig. 10 using examples of

catalysts that can be applied as the catalyst 20 of the catalyst unit 13 in the present embodiment.

As shown in Fig. 10, examples of the catalyst 20 with which the catalyst unit 13 is provided include a metal
5 honeycomb catalyst, a ceramic honeycomb catalyst and a pellet catalyst.

Examples of the metal honeycomb catalyst include a catalyst in which a catalyst-active substance such as a platinum group is added to a honeycomb structure of a metal
10 (Fe-Cr-Al) that is a catalyst base material.

Other examples include a ceramic honeycomb structure of $\text{SiO}_2\text{-Al}_2\text{O}_3\text{-MgO}$ and a pellet structure of $\gamma\text{-Al}_2\text{O}_3$.

The structure of the catalyst of the honeycomb structure will be described using Fig. 7. This is a structure in which
15 a coating agent such as a wash coat is coated on a catalyst base material formed in a honeycomb structure and a catalyst-active substance is adhered to the surface of the wash coat.

Additionally, as shown in Fig. 7, when
20 purification/deodorization target substances (volatile organic matter such as toluene, ethyl oxide, acetaldehyde, and carbon monoxide) have been passed through the catalyst of the honeycomb structure, a catalytic oxidative reaction occurs, the target substances are changed to carbon dioxide
25 and water vapor, and the exhaust gas is purified/deodorized.

Next, a Graph (a) of purified properties (degree of purification with respect to catalyst inlet gas temperature) when the various substances included in the untreated exhaust gas 12 have been purified using the metal honeycomb catalyst and a Table (b) of the concentration and space velocity of the various substances are shown in Fig. 8.

It should be noted that the numbers added to Graph (a) in Fig. 8 correspond to the types of substances shown in Table (b).

Next, the degrees to which the various impurities (gas components) were purified by the catalyst unit 13 of the present embodiment are shown in Table 1 in accordance with the treatment conditions thereof in regard to examples where the exhaust gas components (toluene, n-hexane, ethyl oxide, styrene monomer, formalin) were measured.

[Table 1]

Degree of Purification of Various Components

Component	Concentration before Treatment	Degree of Purification	Catalyst Layer Temperature	S.V.
Toluene	1,200 ppm	99.7%	250°C	20,000 H ⁻¹
	1,200 ppm	99.9% or higher	300°C	20,000 H ⁻¹
	1,000 ppm	98.6%	420°C	40,000 H ⁻¹
n-hexane	2,100 ppm	99.7%	350°C	20,000 H ⁻¹
Ethyl Acetate	1,320 ppm	99.9%	350°C	20,000 H ⁻¹
Styrene Monomer	5,000 ppm	99.9%	350°C	20,000 H ⁻¹

Formalin	100 ppm	99.4%	350°C	20,000 H ⁻¹
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Catalyst used: KT301; degree of purification measured by gas-chromatography; catalyst layer about 15 ml.

With respect to the measurements of Table 1, KT301 (Pt pellet catalyst in which the diameters of the pellets were 2 to 4 mm) was used as the catalyst, and the degree of purification was measured by gas-chromatography under a condition in which the amount of the catalyst was about 15 ml.

Also, a platinum (Pt) group is preferable for the catalyst-active substance used for the catalyst, and examples thereof include Pt, Pd, Ru, Rh, Ir and Os. Fig. 9 is an explanatory diagram showing an example of the purification reaction when platinum (Pt) is used for the catalyst-active substance.

As shown in Fig. 9, a chemical reaction between C_mH_n (hydrocarbon) and O₂ (oxygen) included in the untreated exhaust gas 12 is accelerated by the catalytic action of the platinum (Pt), and the C_mH_n and O₂ are converted to harmless H₂O (water vapor) and carbon dioxide (CO₂) (the symbols "m" and "n" in the aforementioned C_mH_n are integers).

Moreover, the effectiveness according to the various reactions relating to the platinum (Pt) group catalysts is shown in Table 2.

[Table 2]

Pt Group Catalysts Seen According to Reaction (O=effective)

Reaction	Pt	Pd	Ru	Rh	Ir	Os
Hydrogenation Reaction	O	O	O	O	O	
Oxidation Reaction	O	O	O	O	O	
Dehydrogenation Reaction	O	O				
Hydrogenolysis Reaction	O	O	O			
Ammonia Synthesis			O			
Methanol Synthesis		O				
Hydrocarbon Synthesis			O			
Acetic Acid Synthesis				O		
Hydroformylation Reaction			O	O	O	
Carbonylation Reaction				O		
Cis-hydroxylation Reaction						O

In Fig. 3, the "O" mark indicates the type of platinum (Pt) catalyst for which the reaction shown in the

5 corresponding row is effective.

Next, results where manufacture was conducted by the PDP manufacturing method according to the present embodiment and the amounts of various gases (impurities) discharged to the outside (the atmosphere) from the second exhaust pipe

10 14 were measured before and after introducing the catalyst 20 to the catalyst unit 13 of the heat treatment apparatus 10 are shown in Table 3 (before introducing the catalyst) and Table 4 (after introducing the catalyst).

[Table 3]

15 Before Introducing the Catalyst

		Atmospheric Temperature Inside Furnace	100 °C	250 °C	400 °C	400 °C
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Gas Name	Detectable Gas	Exhaust Velocity	6 m/s ec	6 m/s ec	3.7 m/s ec	3.7 m/s ec
		Catalyst Unit Inlet Temperature °C	350 °C	350 °C	350 °C	350 °C
Higher Hydrocarbons	Octane/decane/nonane/hexane/heptane		150	100	150	100
Styrene	Divinylbenzene		2.0	>25	>25	3.0
Ethyl Oxide	Ethyl acrylate/methyl acrylate/isopropyl ether		5.0	100	40	15
Acetone	Brobionaldehyde		0	180	60.0	10.0

Unit: PPM

[Table 4]

After Introducing the Catalyst

Gas Name	Detectable Gas	Atmospheric Temperature Inside Furnace	100 °C	250 °C	400 °C	400 °C
		Exhaust Velocity	6 m/s ec	6 m/s ec	3.7 m/s ec	3.7 m/s ec
		Catalyst Unit Inlet Temperature °C	350 °C	350 °C	350 °C	350 °C
Higher Hydrocarbons	Octane/decane/nonane/hexane/heptane		0	0	0	0
Styrene	Divinylbenzene		0	0	0	0
Ethyl Oxide	Ethyl acrylate/methyl acrylate/isopropyl ether		0	0	0	0
Acetone	Brobionaldehyde		0	0	0	0

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Unit: PPM

It should be noted that GV-100S+NO. 340 (gas sampler and hot probe manufactured by GASTEC Corporation) was used

for the measurements of Table 3 and Table 4 and that a detector tube manufactured by GASTEC Corporation was used for the gas detector tube.

As shown in the measurement results of Table 3,
5 impurities (higher hydrocarbons, acetone, ethyl oxide and styrene) included in the exhaust gas were detected before the introduction of the catalyst. However, as shown in the measurement results of Table 4, when the catalyst was used, impurities (higher hydrocarbons, acetone, ethyl oxide and
10 styrene) included in the exhaust gas were not detected.

As described in detail above, in the present embodiment, the PDP manufacturing method includes forming a structure, wherein the forming of the structure includes forming a precursor layer containing at least one of a resin
15 component and a solvent component on a substrate, and heat-treating the substrate on which the precursor layer has been formed; and decomposing impurities included in exhaust gas generated in the heat treatment by action of a catalyst. Thus, for example, impurities generated in the heat
20 treatment when a structure such as, for example, an electrode, a partition wall, a phosphor layer, a dielectric layer and an outside light reflection prevention layer of a PDP are formed can be purified and discharged to the outside (the atmosphere).

Also, according to the heat treatment apparatus 10 of the present embodiment, the heat treatment apparatus 10 is used in a heat treatment where a substrate, on which is formed a precursor layer including at least one of a resin component and a solvent component, is heat-treated. The catalyst units 5 13 including the catalyst 20 are disposed on exhaust paths where exhaust gases generated in the heat treatment step are discharged. Thus, by using the heat treatment apparatus 10 in the heat treatment when a structure such as, for example, 10 an electrode, a partition wall, a phosphor layer, a dielectric layer and an outside light reflection prevention layer of a PDP are formed, impurities generated in the heat treatment of these can be purified and discharged to the outside (the atmosphere).

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